Different age specific incidence and remission rates in pre-school and primary school suggest need for targeted obesity prevention of childhood

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Short title: Incidence and remission of overweight in children

Key words: body mass index, childhood, incidence, GME, KOPS, obesity, overweight, persistence, remission, school age

Abstract

Background:

School entry marks a tremendous change in the children's life style which might well be relevant for the emergence of overweight. Previous studies suggested a dramatic increase in the prevalence of overweight during this age.

Objective:

To compare the age specific balance between the incidence and remission of overweight between pre-school and primary school age children.

Design:

We combined the data of three studies which had been conducted within the setting of the compulsory school entry health examination in different parts of Germany, one covering retrospective cohort data from age two to school entry (n = 5,045), one prospective data from school entry to fourth grade (n = 1,235), and one both (n = 1,194).We assessed rates of incidence and remission of overweight and obesity from age two to school entry and from school entry to 4^{th} grade.

Results:

In preschool age, the pooled incidence for overweight was 8.2 [95% confidence interval: 7.5, 8.9] % compared to a remission rate of 62.6 [58.4, 66.7] %, yielding a prevalence at school entry of 10.7 [9.9, 11.5] %. In primary school age, the pooled incidence for overweight increased to 14.6 [13.1, 16.1] %, while the remission rate was reduced to 17.7 [13.8, 22.3] % yielding a prevalence of 23.7 [22.0, 25.4] % in fourth grade. A similar pattern was observed for obesity.

Conclusions:

While high remission rates balance incident overweight in pre-school years, the dramatic increase in the prevalence of overweight and obesity in primary school years reflects a higher

incidence and even more a lower remission rate. Obesity prevention programs in primary school age are mandatory and need to address primary and secondary prevention elements.

Introduction

A recent German obesity intervention study from the city of Kiel, called the Kiel Obesity Prevention Study (KOPS), suggested a dramatic increase in the prevalence of overweight during primary school age in its control arm [1], which was even stronger in an East German cohort [2]. These findings correspond to data from the KiGGS survey, a representative nationwide cross sectional study on children and adolescents in Germany. The prevalence of overweight (including obesity) was below 10 % in children at preschool age (3-6 years) but increased to above 15 % in primary school age children (7-10 years)[3].

The prevalence of any medical condition is a reflection of incident cases and remission, when cases revert to normal health or die from the disease. Analogously, prevalence of overweight or obesity at any time point reflects the balance between newly emerging cases (incident cases) and remission from overweight by becoming normal weight during the preceding time period. In individuals without remission from overweight or obesity the condition will persist and persistence can be defined by subtracting the rate of remissions from 100 %. If there are more new, incident cases than remissions the prevalence increases in a defined population.

The distinction between incidence and remission of overweight or obesity is important with respect to preventive strategies against childhood obesity. Already overweight or obese individuals might require a more intensive, targeted intervention than those not overweight yet. Obesity prevention programmes for all children attempting to promote healthy eating and physical activity in primary school age children had indeed limited overall success [4–6]. Could this be explained by the need for a targeted (therapeutic) interventional approach at overweight school age children in whom remission from overweight is poor?

To test the hypothesis that there is a difference in the balance between incidence and remission from overweight between pre-school and primary school age children, we analysed a set of German cohort data. Differences in the balance of incidence and remission of overweight in pre-school and primary school age children might explain the dramatic increase

of overweight after school entry and hint to the need of an age specific approach against childhood overweight.

Materials and Methods

Data

School entry health (SEH) examinations allow for a population based access to large samples of children in preschool age. In Germany, the SEH is usually performed up to one year before children begin to attend primary school.

We had data available from records of n = 7,026 children participating in the SEH in Bavaria, Southern Germany, in 2001/02. Children's age ranged from 54 to 88 months, with 99 % of the subjects in the age of 60-83 months. Together with the invitation to the compulsory SEH, parental questionnaires had been distributed containing questions on sociodemographic variables and early childhood as well as on maternal weight and height. Specifically, parents were asked to copy their offspring's weight measurements at two years from their well baby checkup booklets where the findings of regular free of charge health examinations including anthropometrics are recorded. The response rate was 80.4 %. No follow-up was performed in this study, which has been described in more detail elsewhere [7].

The setting of the SEH was used in the city of Kiel, Northern Germany, to recruit children for the KOPS study between 1996 and 2001. Contrary to SEH study from Bavaria, the invitation to participate in KOPS was not linked to the investigation to the compulsory SEH. Children and parents were directly contacted at the SEH. Due to limited personnel power of the KOPS team, only a part of SEHs could be accompanied and thus used for study recruitment (54.6% of the 12,254 children who participated in the SEH in Kiel between 1996 and 2001 were contacted). Accompanied SEHs were chosen randomly in different districts in Kiel without preferential selection of schools. Of those who were contacted, 74.7% agreed to participate in the study resulting in the collection of data on n = 4,997 children. Age range was between 52 and 93 months, with 99% of the subjects in the age of 63-88 months. This population was shown to be representative for all children in Kiel entering the SEH in these years [8]. Information on weight and height at 2 years was abstracted from the well baby checkup

booklets during the SEH. In addition, mothers self-reported their own height and weight and filled out a questionnaire about sociodemographic variables. A school-based intervention program against the development of obesity was performed in first graders of two to four "intervention schools" per year (1996-2001), within the schools being randomly assigned to the intervention and non-intervention groups. Four years after the respective SEHs (i. e. between 2000 and 2005), 4,487 children were examined during a second compulsory school health examination which took place in the 4th grade (usually at the age of 10 years). Due to privacy policy KOPS was not allowed to directly follow-up (i.e. by name) the children who had been measured at the foregoing SEH. Therefore, the recruitment procedure in the 4th grade was similar to that at the SEH, and 36.6% (n = 4,487) of all 4th graders could be involved in the study. Unfortunately, we were not able to distinguish between non-participation due to refusal or because we did not meet the students (we did not accompany all school health examinations; see above). With the help of the pseudonymized study code, we could identify a total of n = 1,764 children (35 % of the children measured at SEH) who were enrolled in KOPS at school entry as well as in their 4th grade. For the analyses, we used only the data of children attending the non-intervention schools (n = 1,419). More details on KOPS have been described elsewhere [9,10].

Recruitment for the GME (Gesundheits-Monitoring-Einheiten, health monitoring units) survey 2005/06 was also realized within the SEH in a total of six regions (including cities and rural districts) in Bavaria. In one city (Ingolstadt) and one rural district (Günzburg), a second survey was performed in 2009/10 when the children were in their 4th grade. Parents were asked for their consent to retrospectively link these data with the data of the first survey at school entry. In these two study regions, the first survey 2005/06 yielded data of n=2,409 children at school entry including sociodemographic characteristics and maternal weight and height (response rate: 85%). Age range was between 57 and 90 months, with 99% of the subjects in the age of 60-83 months. Details on the study at this stage have been published

elsewhere [11]. Follow-up from SEH to 4th grade was realized in n=1,252 cases (52.0 %). Again, height and weight were measured at this time point. No measurements for the age of 2 years were available in the GME data.

Statistical analyses

For the ages of 2 years, school entry and 4th grade, children's body mass index (BMI) was calculated based on their weight and height measurements. Overweight (including obesity) and obesity were defined based on sex- and age-specific reference values of the International Obesity Task Force [12]. Likewise, we calculated maternal BMI and defined a BMI above 25 kg/m² as maternal overweight. Low parental education was defined as less than 10 years of school education of both parents in all three studies.

We restricted the datasets to those observations providing full information on BMI measurements at 2 years, school entry and 4th grade (KOPS, cases with full information: n = 1,194), BMI at 2 years and school entry (SEH 2001/02, n = 5,045), or BMI at school entry and 4th grade (GME, n=1,235).

We calculated rates of prevalence of overweight and obesity at 2 years, school entry and 4th grade, both sample-specific and in total. Based on these values, we assessed rates of incidence, remission and persistence of overweight and obesity between 2 years and school entry (based on data from KOPS and SEH 2001/02) and between school entry and 4th grade (based on data from KOPS and GME). Persistence of overweight and obesity was defined as 100% minus the respective remission rate. We further calculated 95% binomial confidence intervals (CIs) for all overall estimates of prevalence, incidence, remission and persistence. Additionally, we assessed differences in incidence and remission of overweight and obesity between subgroups defined by sex, parental education and maternal overweight, using Fisher's exact test. In order to assess the interrelation between incidence and baseline BMI

percentile we also compared rates of incidence of overweight and obesity between 2 years and school entry as well as between school entry and 4th grade in children lying in the lower vs. upper half of the sample-specific BMI distribution at the age of 2 years and school entry, respectively. All calculations were carried out with the statistical software R 2.9.0 (http://cran.r-project.org).

Results

The proportion of parents with a low educational status was between 23.7 % and 30.5 % in the individual studies (table 1). The studies were also comparable with respect to proportions of male children as well as with respect to age at school entry and in 4th grade.

In the studies with information about weight status at 2 years (KOPS and SEH 2001/02), the prevalence of overweight (including obesity) increased only slightly until school entry by 2.1 [1.0, 3.1] % (combined cohorts) although the incidence for overweight in this age period was 8.2 [7.5, 8.9] %. This small increase in prevalence could be explained by the high remission rates of 62.6 [58.4, 66.7] % in this age period: while 466 of the 5701 not overweight children at the age of two became overweight until school entry age, 337 of the 538 children overweight at the age of two were no longer overweight at school entry. Remission therefore counterbalanced a substantial part of the incidence of overweight between the age of two and school entry (table 2). With respect to obesity, similar results were observed, with an even higher remission rate (73.5 [62.7, 82.6] %).

In contrast, the prevalence of overweight increased considerably between school entry and the age of ten by 10.2 [8.0, 13.1] % (combined cohorts). This considerable increase in prevalence was based on a 14.6 [13.1, 16.1] % incidence for overweight in this age period which was not balanced by the remission rate of only 17.7 [13.8, 22.3] %: while 306 of the 2102 not overweight children at school entry became overweight by the age of ten, only 58 of the 327 children overweight at school entry were no longer overweight at the age of 10 (table 3).

Consequently, the contribution of persistence of overweight to the overall prevalence of overweight was significantly higher in primary school age (269/575 = 46.8 [42.6, 51.0] %) than in preschool age (201/667 = 30.1 [26.7, 33.8] %). This was even more pronounced for persistence of obesity (48/112 = 42.9 [33.5, 52.6] % compared to 22/181 = 12.2 [7.8, 17.8] %).

Rates of incidence of overweight (including obesity) were similar in male and female children, but significantly ($p<0.05$) increased in children of parents with low education and in children of overweight mothers (table 4). Rates of remission were lower in the latter two groups (only borderline significant). Analyses for incidence and remission of obesity yielded equivalent results (data not shown).

The incidence rates of overweight and obesity were significantly higher in children starting in the upper half of the BMI distribution compared to those in the lower half of the BMI distribution in both periods examined (table 5). In the latter, the rates of incidence of overweight and obesity were below 5 % and 1 %, respectively. The incidence for overweight in children in the upper half of the BMI distribution at school entry (28.7 [25.8, 31.9] %) was considerably higher than in children in the upper half of the BMI distribution at the age of two (13.0 [11.7, 14.3] %).

Discussion

The presented cohort data confirm a considerably higher prevalence of overweight and obesity in ten year old compared to preschool children in Germany. The low prevalence of overweight and obesity in preschool children reflected an almost balanced emergence (incidence) and remission of overweight and obesity in the age range from two years to school entry. The considerable increase in the prevalence of overweight / obesity during primary school age in our data could only partially be explained by higher rates of incidence. Considerably lower remission rates during primary school age, which were consistently observed in two cohorts recruited in different regions in Germany, were at least equally important. Low remission rates and high incidence rates were most pronounced in children of parents with low education and of overweight mothers, while no sex-specific effects were observed.

There are only very few studies addressing age specific incidence and remission of overweight / obesity in childhood. Nader et al. analysed the probabilities of overweight at the age of 12 as function of BMIs at an earlier age [13]. While less than half of the children with a BMI above the 85th percentile at the age of two years were overweight at the age of 12 years, this probability increased to almost 80% by the age of seven. These observations match our findings of a considerably higher persistence of overweight in school age children compared to toddlers. Kim et al. analysed age specific incidence and remission rates for a one year observation period school age children [14]. As in our data the remission rates were low.

Our analyses go beyond these studies by addressing the age specific balance of incidence and remission of overweight in pre-school and school age children, demonstrating that increased persistence of overweight in school age children may explain the substantial increase the prevalence of overweight / obesity in primary school children. Similar patterns with a higher prevalence of overweight / obesity in children at primary school age were observed in cross-sectional studies in Norway [15] and Finland [16] and less so in Ireland [17]. Cross-sectional data

from Japan [18] and Hungary [19] on primary school children showed increasing rates of overweight in pre-pubertal years.

These findings have important implications for the concepts on emergence of childhood obesity and intervention strategies against childhood obesity. The main argument for interventions against obesity in preschool children is based on lifetime courses of BMI or other markers of childhood obesity in overweight or obese children and adolescents. These analyses were based on comparisons of the time course of age specific mean BMI in overweight or non overweight adolescents [20,21]. In children who were overweight later in life higher average BMI values started to emerge in preschool years, reflecting fairly good BMI tracking over the life cycle [22]. However, not all overweight toddlers will be overweight by the age of ten, and many of those overweight by the age of ten have not been overweight at an early age. Our approach, applying age specific incidence and remission (persistence) rates allows analysing the mechanisms for increasing prevalence of overweight in primary school age children. While incidence and remission of overweight appeared to be almost balanced in preschool years, this balance appeared to become shifted in primary school years due to increasing incidence and lower remission rates.

A further interesting finding pertains to the interrelation of the BMI distribution - upper versus lower half - at the age of two or at school entry and the incidence of overweight and obesity in subsequent years. While only few children with a BMI in the lower half of the distribution became overweight in the subsequent four year time period, the respective incidence was considerable for those in the upper half: about one out of seven of the 2-year olds and almost one out of four of the respective children at school entry became overweight in the subsequent four year time period. Therefore also children with a BMI between the 50^{th} and 90^{th} percentile at school entry might need to be targeted in intervention programmes.

Strengths and limitations:

It is unlikely that our results were prone to selection bias, since both the KOPS [8] and the GME data were based on representative samples and more than 80 % of the target populations had been captured for the Bavarian SEHs of 2001/02.

Low follow-up from school entry to 4th grade, however, might introduce selection bias. The reason for this lower follow-up was partly related to the data collection strategy. Children were not individually tracked. There were losses to follow-up due to families moving out of the region, non attendance on the particular day of the measurement or due to some schools withdrawing their permission for measurement in the fourth term (in the KOPS study). While these causes of loss to follow up are not likely to account for bias, noncompliance of individual children might be related to the main outcomes incidence and remission of overweight and therefore account for bias.

In order to assess potential bias by loss to follow-up, we compared sociodemographic characteristics of children with and without successful follow-up. In the KOPS study, the children not followed up had more often parents with a low educational status compared to children followed up (40.4 % compared to 24.4 %, Fisher's exact test: $p<0.01$). In the GME study, low educational status was also more often recorded in parents of children not followed up (28.7 % compared to 23.7 %, $p<0.01$). However, rates of incidence were higher and rates of remission were lower in children of parents with low educational status. Therefore bias due to lower compliance in children of parents with low educational status is towards unity suggesting that our data would rather under- than overestimate the incidence and persistence of overweight in primary school age children.

It would be ideal to run these analyses on a "complete" cohort followed up from infancy to the end of primary school age. The KOPS cohort has the advantage of having identical children assessed both in the first (preschool) and in the second (primary school) four-year periods. The drawback of this cohort is that follow-up during primary school age was low.

The SEH data provide confirmation of the preschool KOPS findings in a different sample capturing 80.4 % of the preschool target population. The GME data confirm the KOPS findings from Northern Germany in clearly distinct urban and rural regions in Southern Germany. Therefore and because of the consistency of the remission rates in different cohorts, the observed patterns of differences in remission of overweight in preschool and primary school children are likely to be internally valid.

External validity might be an issue, since these data have been generated in one country only. Although there are limited data on the increase in the prevalence of overweight during primary school years, most available data from other countries suggest a similar increase in the prevalence during primary school years[15–19]. This is plausible, since a switch to sedentary life style marks school entry everywhere. Therefore our data are likely to be externally valid.

Conclusions:

Primary school age is critical for the development of overweight and obesity in childhood. The increase in prevalence during this age period does not appear to reflect solely a higher age specific incidence, but at least equally a higher persistence of overweight / obesity. Preventions targeting the occurrence of overweight / obesity in normal weight children may need to be supplemented by interventions targeted at children already overweight in primary school age.

Acknowledgements

The authors' responsibilities were as follows: RvK contributed the study concept and analysis plan. AB performed data management and statistical analyses together with AC and wrote the first and final draft of the paper together with RvK. MJM, SPD and BL provided the data from the KOPS study and contributed to subsequent drafts of the paper. JH contributed to subsequent drafts of the paper. GB provided the data from the GME study and contributed to the final draft of the paper. RvK, AB and AC had full access to all of the data in the study and can take responsibility for the integrity of the data and the accuracy of the analysis.

None of the authors had a conflict of interest.

This paper was supported by the Ludwig-Maximilians University Innovative Research Priority Project Munich Center for Health Sciences (sub-project 1),
KOPS was funded by Deutsche Forschungsgemeinschaft (DFG Mü 5.1, 5.2, 5.3 und 5.5).
„Kompetenznetz Adipositas (Competence Network on Obesity)" was funded by the Federal Ministry of Education and Research (FKZ: 01GI0821).
The GME cohort study was funded by the health initiative „Gesund.Leben.Bayern." of the Bavarian State Ministry of the Environment and Public Health, Munich, Germany. The authors thank all parents for participating in the surveys.

Study Group of the GME cohort
Bavarian Health and Food Safety Authority, Munich (Gabriele Bolte, Hermann Fromme, Lana Hendrowarsito, Nicole Meyer); Health Authority of the District Office of Guenzburg (Tatjana Frieß-Hesse, Franziska Lang, Roland Schmid, Gudrun Winter); Health Authority of the City Ingolstadt (Christine Gampenrieder, Margot Motzet, Elisabeth Schneider, Traudl

Tontsch, Gerlinde Woelk); Institute of Social Paediatrics and Adolescent Medicine, Ludwig-Maximilians-University Munich (Ladan Baghi, Otmar Bayer, Rüdiger von Kries).

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TABLE 1. Study characteristics of the studies analyzed. Percentages are related to non-missing values.

	KOPS	**SEH 2001/2002**	**GME**
Sample size, n	1194	5045	1235
Male children, n (%)	594 (49.7 %)	2614 (51.8 %)	625 (50.6 %)
Low parental education, n (%: if information available)	291 (24.4 %) [missing: n=0]	1485 (30.5 %) [missing: n=171]	274 (23.7 %) [missing: n=80]
Maternal overweight, n (%: if information available)	274 (27.0 %) [missing: n=178]	1255 (26.3 %) [missing: n=275]	318 (28.0 %) [missing: n=100]
Mean (SD) age at 6 years [y]	6.2 (0.4)	6.0 (0.4)	6.0 (0.4)
Mean (SD) age at 10 years [y]	10.0 (0.5)	NA	10.0 (0.4)

NA: data not available

TABLE 2. Rates of prevalence, incidence, remission and persistence of overweight (including obesity) and obesity between the age of 2 years (initial) and school entry (final), with 95% confidence intervals of total proportions in square brackets.

		KOPS	**SEH 2001/2002**	**Total**
Overweight	Initial prevalence	143/1194 (12.0 %)	395/5045 (7.8 %)	538/6239 (8.6 [7.9, 9.3] %)
	Final prevalence	149/1194 (12.5 %)	518/5045 (10.3 %)	667/6239 (10.7 [9.9, 11.5] %)
	Incidence	94/1051 (8.9 %)	372/4650 (8.0 %)	466/5701 (8.2 [7.5, 8.9] %)
	Remission	88/143 (61.5 %)	249/395 (63.0 %)	337/538 (62.6 [58.4, 66.7] %)
	Persistence	55/143 (38.5 %)	146/395 (37.0 %)	201/538 (37.4 [33.3, 41.6] %)
Obesity	Initial prevalence	23/1194 (1.9 %)	60/5045 (1.2 %)	83/6239 (1.3 [1.1, 1.6] %)
	Final prevalence	36/1194 (3.0 %)	145/5045 (2.9 %)	181/6239 (2.9 [2.5, 3.3] %)
	Incidence	27/1171 (2.3 %)	132/4985 (2.6 %)	159/6156 (2.6 [2.2, 3.0] %)
	Remission	14/23 (60.9 %)	47/60 (78.3 %)	61/83 (73.5 [62.7, 82.6] %)
	Persistence	9/23 (39.1 %)	13/60 (21.7 %)	22/83 (26.5 [17.4, 37.3] %)

TABLE 3. Rates of prevalence incidence, remission and persistence of overweight (including obesity) and obesity between school entry (initial) and age of 10 years (final), with 95% confidence intervals of total proportions in square brackets.

		KOPS	**GME**	**Total**
Overweight	Initial prevalence	149/1194 (12.5 %)	178/1235 (14.4 %)	327/2429 (13.5 [12.1, 14.9] %)
	Final prevalence	259/1194 (21.7 %)	316/1235 (25.6 %)	575/2429 (23.7 [22.0, 25.4] %)
	Incidence	137/1045 (13.1 %)	169/1057 (16.0 %)	306/2102 (14.6 [13.1, 16.1] %)
	Remission	27/149 (18.1 %)	31/178 (17.4 %)	58/327 (17.7 [13.8, 22.3] %)
	Persistence	122/149 (81.9 %)	147/178 (82.6 %)	269/327 (82.3 [77.7, 86.2] %)
Obesity	Initial prevalence	36/1194 (3.0 %)	41/1235 (3.3 %)	77/2429 (3.2 [2.5, 3.9] %)
	Final prevalence	42/1194 (3.5 %)	70/1235 (5.7 %)	112/2429 (4.6 [3.8, 5.5] %)
	Incidence	23/1158 (2.0 %)	41/1194 (3.4 %)	64/2352 (2.7 [2.1, 3.5] %)
	Remission	17/36 (47.2 %)	12/41 (29.3 %)	29/77 (37.7 [26.9, 49.4] %)
	Persistence	19/36 (52.8 %)	29/41 (70.7 %)	48/77 (62.3 [50.6, 73.1] %)

TABLE 4. Total overall rates (pooled data from KOPS and GME) of incidence and remission of overweight (including obesity) during primary school age in subgroups defined by sex, parental SES and maternal overweight (if information available) with 95% confidence intervals in square brackets. P-values were derived from Fisher's exact test.

		Yes	**No**	**p-value**
Incidence	Male children	159/1067 (14.9 [12.8, 17.2] %)	147/1035 (14.2 [12.1, 16.5] %)	0.67
	Low parental education	88/449 (19.6 [16.0, 23.6] %)	200/1585 (12.6 [11.0, 14.4] %)	<0.01
	Maternal overweight	90/489 (18.4 [15.1, 22.1] %)	178/1372 (13.0 [11.2, 14.9] %)	<0.01
Remission	Male children	29/152 (19.1 [13.2, 26.2] %)	29/175 (16.6 [11.4, 22.9] %)	0.57
	Low parental SES	15/116 (12.9 [7.4, 20.4] %)	43/199 (21.6 [16.1, 28.0] %)	0.07
	Maternal overweight	13/103 (12.6 [6.9, 20.6] %)	40/187 (21.4 [15.7, 28.0] %)	0.08

TABLE 5. Rates of incidence of overweight (including obesity) and obesity between 2years (initial) and school entry (final) as well as between school entry (initial) and age of 10 years (final) in children lying in the lower vs. upper half of the sample-specific BMI distribution at the age of 2 years and school entry, respectively, with 95% confidence intervals of total proportions in square brackets. P-values were derived from Fisher's exact test.

		Lower half	**Upper half**	**p-value**
2 years – school entry	Overweight	131/3120 (4.2 [3.5, 5.0] %)	335/2581 (13.0 [11.7, 14.3] %)	<0.01
	Obesity	23/3120 (0.7 [0.5, 1.1] %)	136/3036 (4.5 [3.8, 5.3] %)	<0.01
School entry – 10 years	Overweight	51/1215 (4.2 [3.1, 5.5] %)	255/887 (28.7 [25.8, 31.9] %)	<0.01
	Obesity	1/1215 (0.1 [0.0, 0.5] %)	63/1137 (5.5 [4.3, 7.0] %)	<0.01